PROGRESSIVE RESOURCE PROSPECTING CAMPAIGNS FOR LUNAR-DERIVED RESOURCES A.J. Gemer[1], J.A. Cyrus[1], F. Meyen[1], and J.B. Cyrus[1], [1]Lunar Outpost, Inc. (12555 W. 52nd Ave, Arvada, CO 80002, AJ@LunarOutpost.com)

Introduction: With recent landings of CLPS and international lunar landers, space resources technology demonstrations leading to future extraction and utilization campaigns, are steadily advancing in both frequency and maturity. Supporting those utilization activities is a campaign of mobile instrument suites intended to characterize the forms, distributions, and accessibility of a range of lunar-derived feedstocks, ores and materials. Data from these precursor missions are crucial to inform the priorities, policies, and mission architectures for future large-scale resource operations on the lunar surface.

Lunar Voyage 1 (LV1): Lunar Outpost's Lunar Voyage 1 will be the first privately-owned rover to traverse near the Moon's South Pole. The novel rover platform, the Mobile Autonomous Prospecting Platformed (MAPP), will explore Shackleton Connecting Ridge and collect a unique scientific data set that will further our understanding of the lunar polar environment. The LV1 MAPP (*Fig. 1)* will be delivered to the lunar surface by a lander built by Intuitive Machines during the upcoming 2024 IM-2 mission that will also deliver NASA's PRIME-1 drill to the lunar surface. The LV1 MAPP hosts several resource-focused payloads, including the RESOURCE camera created by the Massachusetts Institute of Technology and NASA Ames. This instrument is a sold-state depth sensor/LiDAR, capable of collecting 12-megapixel color enhanced with 1-megapixel time of flight depth data. This sensor will produce high resolution depth images for lunar geology and enable ground-based VR simulations of surface observations, delivering some of the first data on lunar resource forms and distributions in the lunar south pole region.

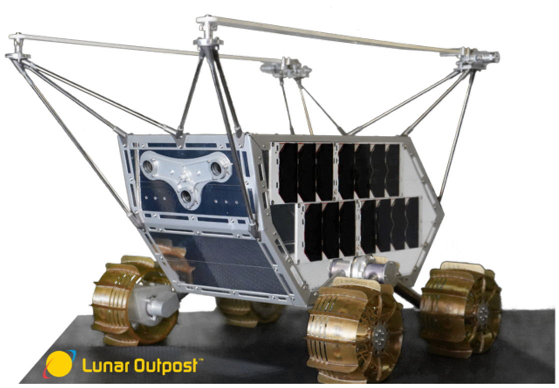


Figure 1: Lunar Voyage 1 MAPP Rover

To add science and prospecting context to the resource-focused instrumentation, MAPP is equipped with dual stereoscopic navigation cameras that will be used to map the lunar surface during the traverse. These cameras can be used to synthesize images in 3D and are optimized for observing geologic features several meters in front of the rover. The LV1 MAPP also hosts a thermal camera for observation of surface temperature profiles in lit and unlit regions of interest, providing context on potential micro-PSRs along its traverse.

Figure 2: Resource Collection Hopper; View from MAPP Wheel Observation Camera

NASA Resources Collection and Transfer: During Lunar Voyages 1 and 2, MAPP will collect lunar regolith in a transparent collection hopper mounted inside one of the rover's wheels (*Fig. 2*), then perform an in-place transfer of ownership of the material from Lunar Outpost to NASA. This is a key pathfinder activity for space resources, demonstrating the legal and procedural framework to enable future large-scale lunar resource transactions. The regolith collection hopper aboard the LV1 and LV2 MAPPs has been flight-qualified and demonstrated in a relevant environment, resulting in the collection of 140 grams of regolith simulant at 1.36 g/cm^3 over 2 meters of driving.

Lunar Voyage 2 (LV2): LV2 is a NASA-funded science and exploration mission to the near-equatorial Reiner Gamma site, with the LV2 MAPP providing mobility for the JHU APL Lunar Vertex PRISM-1a instrument suite. This suite includes the Vector Magnetometer – Rover (VMR – *Fig. 3, Top*) instrument to characterize the surface magnetic field, as well as the Rover

Multispectral Microscope (RMM). RMM data, consisting of spectral imaging data in the wavelength range 0.34-1.0 µm, will provide insights into the composition, texture, and particle size distribution of surface regolith, expanding relevant resource prospecting capabilities.

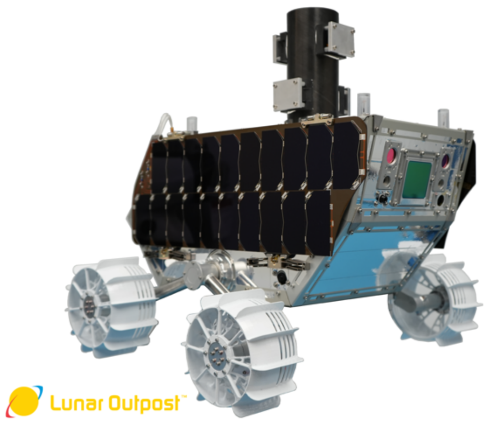


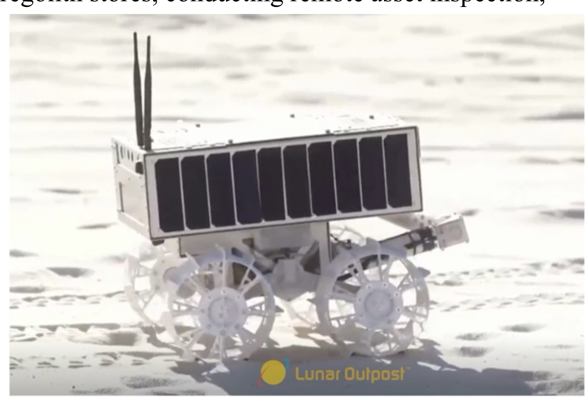
Figure 3: Lunar Voyage 2 MAPP – Lunar Vertex PRISM-1a Mission

Lunar Voyage 3 (LV3): LV3 builds on the heritage of prior MAPP missions, while increasing capabilities and fidelity of resource measurement and in-situ analysis. LV3 is scheduled to launch in 2025; payload space is currently available aboard the LV3 MAPP (*Fig. 4*) for integration of additional resource prospecting instrumentation from commercial and institutional payload providers who wish to validate key prospecting technologies and return valuable lunar resource data to inform future extraction activities.

Figure 4: Lunar Voyage 3 MAPP Rover

ASA Trailblazer: The Australian Space Agency (ASA) has launched the Trailblazer initiative under its Moon to Mars program to develop new capabilities in the Australian space sector, including foundation services for lunar exploration missions. The initiative aims to demonstrate and progress Australian exploration capabilities with remotely operated and autonomous Australian robotic lunar assets, contributing to NASA's Artemis program. The Consortium led by Lunar Outpost Oceania has been selected for Stage 1 of the initiative, which includes the development of a foundation services rover platform capable of collecting lunar regolith and delivering it to a NASA in-situ resource utilization facility. Lunar Outpost Oceania is working with a consortium that includes EPE, BHP, Northrop Grumman Australia, RMIT University, the University of Melbourne's Space Laboratory and others to advance the Trailblazer rover platform (*Fig. 5*) to flight readiness by 2026.

The primary objective of the Trailblazer lunar rover is to deliver lunar regolith to the ISRU facility on the surface of the Moon. This requires the rover to survey the environment, locate and acquire the resource-rich regolith, transport it to the designated delivery zone, and deposit it at the ISRU facility. The rover will repeat this process until the required amount of regolith is delivered. Additional tasks that will be performed by the rover include wide-area resource prospecting, loading and unloading regolith, constructing regolith stores, conducting remote asset inspection,



and performing surface preparation for infrastructure operations.

Figure 5: Lunar Outpost Oceania Trailblazer Rover, during Remote Operations Demonstration from the US to Australia in March 2024

Ongoing Campaign Missions: Future missions beyond Trailblazer will further expand resource prospecting, collection, delivery, and processing capabilities, with larger rovers, longer mission durations, and greater areal coverage. New instrument capabilities provide deep subsurface measurement and analysis, while new rover architectures allow greatly expanded terrain access to regions of science and resource interest such as Gruithuisen Domes and Permanently-Shadowed Regions (PSRs). These missions reduce risk and improve cost-effectiveness by leveraging high-heritage technologies validated aboard prior MAPP missions, at polar to equatorial lunar latitudes.